

improvements in technology to arrive at spectrum demand over time. Variables were assumed to vary equally for voice, data, and messaging, except that the COD for data was retained at 1.0 rather than 2.0 for voice and messaging. The normalized values used in the following equation to calculate the yearly factor "F."

$$F = \frac{(ERL)(POP)(SRC)}{(COD)(RATE)(ERR)}$$

Page A.2 of Appendix A shows the results of the factor calculation and its effect on yearly demand in Los Angeles. The next pages in the Appendix apply the new yearly demand for Los Angeles to other cities for the years 1997, 2000, and 2005 (pages A.3, A.4, and A.5)²³. The next chart of the Appendix list the demands by city and year (page A.6). The last chart backs out the 2.5 MHz for interoperability for reasons to be discussed in the following sections (page A.7).

The analysis in Appendix A (page A.7) shows that the greatest need for public safety spectrum is now. By 2010, only three cities (New York, Los Angeles and Chicago) will require more than 6.0 MHz of new spectrum.

There are two factors, however, that could alter this projection. First, the public safety community has few, if any, incentives at this time to move to the more efficient technologies assumed by the PSWAC. If old technologies continue to be used indefinitely, the demand for spectrum will increase from today forward as the demand for traffic increases. The importance of changing to new technologies in a timely manner cannot be overstated. For example, in Los Angeles, if the traffic load increases as predicted but existing technology parameters are considered, the spectrum demand below 1,000 MHz would be 121.7 MHz.²⁴ This is quite a discrepancy from the 37.8 MHz from the PSWAC projections. Similar projections would apply for other cities as well.

Second, policy makers may determine that it is desirable to allocate more spectrum to public safety operations in order to bring most operations into a common band. If this turns out to be the case, many of the existing allocations would be vacated in favor of some nationwide contiguous spectrum. For purposes of further analysis in this report,

²³Note that the population ratios between cities were taken as the 2010 ratios for all years for ease of calculation. Additionally, the only other population data in the PSWAC Final Report was for 1990, not 1996 or 1997.

²⁴ This figure applies all of the assumed parameters of today's equipment to the Erlang load and population anticipated for 2010.

it is assumed that the public safety community will change out equipment and that there will be no migration to a common, nationwide band, except for the interoperability channels.

ANALYSIS OF SPECTRUM OPTIONS IDENTIFIED BY THE PSWAC

Voice, Data, Messaging, and Video Requirements. The PSWAC Final Report identified eight options for meeting spectrum needs below 1,000 MHz.²⁵ The options are as follows:

1. Immediate further sharing of TV channels in the 470 - 512 MHz band in all areas.
2. Reallocate all or part of 746 - 806 (broadcast channels 60 - 69) MHz band.
3. Immediate allocation of the VHF and UHF channels in other services created by the FCC's Refarming Proceeding (including TV sharing bands).
4. Eventual reallocation of all TV sharing channels in the 470 - 512 MHz band.
5. Immediate new sharing of the 174 - 216 MHz VHF TV band primarily outside of urban areas and for statewide systems.
6. Reallocation of the 380 - 399.9 MHz band.
7. Sharing of the 380 - 399.9 MHz band with DOD on a mutually agreeable basis to minimize interference to public safety operations.
8. Hold a portion of the 174 - 216 MHz band in reserve to meet future public safety needs, or needs not met by this effort.

Five of the options involve additional use of television broadcast channels, two options suggest use of Department of Defense (DoD) frequencies, and one option reallocates existing land mobile spectrum from non-public safety use to public safety use. The following is an analysis of various spectrum options to satisfy public safety needs.

Interoperability Frequencies. The first consideration for new spectrum should relate to interoperability. While spectrum shortages for any specific agency can be critical to operations, the inability of different agencies to communicate can be detrimental to entire communities or the country. Particularly in times of disaster recovery, it is critical that all affected agencies have the ability to communicate with each other. There is almost no opportunity for this to occur today. The PSWAC Final Report called for 2.5 MHz of new spectrum to be dedicated to interoperability and suggested that the spectrum be below 512 MHz.²⁶

²⁵ See PSWAC Final Report, § 4.4.16.

²⁶ See PSWAC Final Report, §§ 4.3.27.1 and 4.4.1.

Because the need is immediate and the spectrum must be common throughout the United States, it should come from a band that can be cleared and reallocated as quickly as possible. In addition, this is the only new spectrum in which the federal government will have regular access. For these reasons, it would be appropriate for the spectrum to come from the federal bands. The band from 225 - 420 MHz is currently utilized exclusively by the federal government, primarily DoD. The PSWAC Final Report recommends consideration of the 380 - 399.9 MHz band for either reallocation or sharing with DoD. Spectrum in this band is also being considered in Europe for a similar type of allocation.

Regardless of the current use of that band by DoD, the use by one federal department can hardly compare to the overall health and safety of the citizens of the country as provided by the thousands of federal, state, and local public safety agencies. In fact, the ability of such agencies to communicate directly with DoD would be beneficial in those instances in which the DoD assists in disaster restoration. The suggested reallocation would also meet the requirements of the PSWAC Final Report for establishment of a new interoperability band (the PI band).

There are other possibilities for interoperability channels; however, they are less desirable than the one just described. For example, some more interoperability channels could come from the "Refarmed" channels below 512 MHz. Because the FCC has not mandated specific cut-over dates, finding common, nationwide channels in these bands will be very difficult, if not impossible, for the near term. Conversions to new technology will vary community-by-community.

A similar problem exists for the possible use of television channels 14 - 20. Clearing common spectrum throughout the nation cannot be done immediately. As will be explained below, such an approach is contrary to any television reallocation plan currently being considered. Finally, use of spectrum in television channels 60 - 69 would face the clearing issue as well as not meeting the requirement of being under 512 MHz.

Thus, given the difficulties with the non-DoD bands being considered, the best option for interoperability solutions would be for reallocation or sharing of 2.5 MHz of the 380 - 399.9 MHz band. This band meets the PSWAC requirement of being below 512 MHz; it is adjacent to a widely used existing federal band (400 - 420 MHz); DoD can easily share the band; and, equipment can easily be made available for use in the band (either stand-alone radios or multi-band radios). Alternatively, fixed infrastructure gateway devices can translate existing channels to the interoperability band in time of need.

Refarming Options. The FCC's Refarming proceeding has the potential to create up to four times the channel capacity for private land mobile radio users within the next ten

years in the bands below 512 MHz. The FCC implemented a plan to require new equipment designs to meet more stringent spectrum efficiency standards. Beginning in February 1997, newly certified equipment must meet a 12.5 kHz bandwidth, or equivalent, standard. In 2005, a 6.25 kHz bandwidth, or equivalent, bandwidth must be met. This approach allows for either narrow band equipment or wider band equipment, like TDMA, which can support four voice channels in a 25 kHz bandwidth. The Commission's approach of requiring newly certified equipment to meet more efficient technical standards should bring about a transition to the more efficient equipment over time. The question is, however, how long will it take before any benefits are seen from the Commission's approach to Refarming? The answer is likely to be, "a very long time."

To date, the FCC has provided no real incentives to licensees to convert to more efficient technologies. No mandatory cut off dates for use of existing equipment were adopted. The FCC did not even stop the manufacturing of 25.0 kHz equipment that was certified prior to January 1997. This means that not only can existing equipment continue to be used indefinitely, new equipment can be purchased for 25.0 kHz channels for an indefinite period. Because newly certified and manufactured equipment that is more spectrally efficient may be more costly than older style equipment, licensees may choose to stay with 25.0 kHz FM.

The major operational incentive for a licensee to convert today would be to attempt to gain more capacity from currently authorized channels. That may be sufficient incentive for large organizations with expanding communications needs, but it provides almost no incentive for the small licensees. The FCC has proposed granting some limited channel exclusivity or protected service areas for licensees that convert to newer technology. That type of protection from new users on the channel could provide incentive, but in major markets it will be hard to get all existing users on a channel to agree to convert to new technology and thus gain exclusivity. Those wanting exclusivity will likely move to the new splinter channels created by Refarming rather than try to convert to newer technologies on existing channels. But, the option for exclusivity has not yet even been granted by the FCC.

Moreover, Refarming did not address the 800 MHz and 900 MHz land mobile bands. The 800 MHz band remains on a 25.0 kHz standard, and the 900 MHz band is on a 12.5 kHz standard. Both bands should be considered for Refarming efficiency guidelines. With the proper incentives, these bands could further help alleviate some of the public safety spectrum requirements. Even if no incentives are provided for conversion to new technology in the existing bands beyond those already in place, any new spectrum licensed to a public safety entity should have a required 6.25 kHz efficiency standard. It makes no sense to propagate less efficient equipment into new spectrum only to have it remain on the air for a decade or more before it is changed out.

The efficiencies to be realized from the Refarming, including the 800 MHz and 900 MHz bands, can provide immediate gains in capacity on the public safety channels. Moreover, land mobile spectrum in the non-public safety bands could be made available for public safety use in the most congested areas. In this way, public safety gains a double benefit from Refarming, but only if licensees actually convert to more efficient technologies in a timely manner.

The Commission also has proposed some sort of spectrum fee that would favor narrow bandwidth equipment operating over the minimum needed geographic area. Such fees would require Congressional authority. The potential for securing that authority is unknown, and such fees would probably not apply to public safety.

So the real opportunity for "green space" spectrum from Refarming through voluntary incentives is small. Mandatory equipment change out times or other incentives outlined above, at least in major markets, would help ensure that Refarming (including in the 800 MHz and 900 MHz bands) accomplishes its stated goals in a reasonable time frame. In any event, any new spectrum should have a 6.25 kHz bandwidth equivalent requirement for licensing.

Television Channel Sharing. The PSWAC Final Report bases most of its possibilities for new public safety spectrum on additional spectrum coming from television channels, either through reallocation or more sharing. Because of the complexity of the issue, it will be treated as a separate section of this report, beginning with some background information about the changes in the television industry that are predicted.

TELEVISION CHANNEL SHARING OPTIONS

Traditional Sharing. Television channels 14 - 20 have been shared with land mobile stations in eleven major markets for years. Sharing is accomplished primarily through minimum mileage separations between allotted television channels and areas of land mobile operation. Except for Los Angeles and New York, each of the eleven cities has one or two television channels assigned for land mobile use. The channels are shared between all land mobile services, including public safety. In the case of New York and Los Angeles, each city has one additional television channel assigned exclusively for public safety operations. Sharing arrangements have worked well over the years to provide the land mobile community with needed spectrum without interference to television stations broadcasting with the traditional, non-digital format (National Television Systems Committee (NTSC) format).

Recent developments in digital television (DTV) have led to the need for alternate channels to be allocated for broadcast transmission of the DTV signals. Essentially, for a

transition time each existing station would be provided a transition channel to begin DTV operations. This has led to development of some new channel plans for television allotments and renewed interest in the television spectrum by the land mobile community.

Advanced Digital Television. During roughly the same time period that the public safety community grappled with its spectrum needs, the broadcast television community worked to develop an advanced television transmission system.

The promise of High Definition Television (HDTV) has been a goal of the broadcast television community for more than a decade. Through the work of the Advanced Systems Television Committee and the corresponding Advisory Committee on Advanced Television Services, sponsored by the FCC, a transmission standard was recently adopted. Much of the work that led to adoption of a standard was done by the Advanced Television Test Center. The Center's testing of the "Grand Alliance System" and its findings finally permitted agreement on a transmission technology. The FCC largely adopted this technology as a standard, making television use of the spectrum more efficient and ultimately by freeing some existing television spectrum for other uses.

FCC Channel Plan. The FCC determined that each television broadcaster should be granted a second six megahertz channel for transmission of advanced television signals in return for relinquishing one of the two channels. Because the new technologies did not require as much distance separation between adjacent channels stations, the Commission saw the opportunity to revise completely its allotment table of television assignments.

In the Sixth Further Notice of Proposed Rule Making (Sixth Notice) in FCC Docket 87-268 (August 14, 1996), the FCC proposed a "DTV core channel plan" that would permit reallocating television channels 2-6 and 52-69 to other services. The remaining channels would, according to the FCC, accommodate all existing television broadcasters with new channels capable of digital television transmission with service areas comparable to their existing NTSC coverage. The core plan would continue to use channels 60-69 in about 30 cases to ensure that all existing broadcast television stations have a DTV transition channel. The core plan also would provide some protection for existing broadcasters in channels 60-69 until they could relocate to channels below 60.²⁷ The plan would allow land mobile sharing with co-channel distances of 155 miles and

²⁷ See Sixth Notice at paragraph 26.

adjacent channel distances of 110 miles.²⁸

The Commission's plan has met resistance among broadcasters. The broadcast community generally feels that the core plan does not provide adequate interference protection to service areas. Many in the land mobile community, on the other hand, feel that the Commission's plan is too conservative.²⁹ Two alternative allotment tables were submitted to the FCC and are now under consideration. One plan was submitted by the broadcasting industry in the Broadcasters' comments. The other was submitted by Motorola. The difference between the land mobile community's and the broadcasters' plans centers around whether television channels 60-69 can be reallocated immediately or in the near future for land mobile use without a disruption to over-the-air television services.

Broadcasters' Channel Plan. The broadcasters would continue to use all existing channels in the reallocation plan. However, they contend under a "modified plan" that with only 124 modifications to the FCC's table, interference to existing NTSC stations would be reduced from 499,780 sq. km. to only 381,881 sq. km.³⁰ This would be a 31 per cent reduction in interference areas. Potential interference to new DTV stations would be reduced from 685,349 sq. km. to only 467,224 sq. km., or a 47 per cent reduction. This modified plan continues the FCC's goal of minimizing use of channels 60-69 to the extent considered possible. The plan also protects all but one of the existing land mobile shared channels (channels 14-20 in major markets) to a protection distance of 240 km. The broadcasters would prefer, however, to reallocate one or two of the land

²⁸ The FCC plan did not actually achieve the proposed adjacent channel separation in all cases.

²⁹ Several land mobile commenters offered variations on the FCC core plan. For example, John Powell and Ericsson, Inc. suggested that television channels 7 and 8 should be left out of the core channels. They would also leave out channels 14-18. They contend that these channels are adjacent to heavily used land mobile channels and could easily accommodate expansion of land mobile operations. The California Department of General Services would further eliminate channels 6, 19, and 20 from the core channels. Motorola was the only land mobile entity that provided an alternative new allotment plan. Motorola's plan essentially eliminated use of channels 60 - 69.

³⁰ The comparisons are actually to a "baseline table" which makes minor corrections to the FCC's core table. See Broadcasters' Comments on the Sixth Notice of Proposed Rulemaking (Broadcast Comments), footnote 52.

mobile shared channels for exclusive public safety use.³¹

One of the more interesting exhibits in the Broadcast Comments is Appendix D2. In that appendix, maps are presented that show available spectrum in channels 60-69 under the FCC's plan, as corrected, and under the modified plan. Because the FCC did use channels 60-69 for some DTV stations and would protect NTSC stations in that band, even the FCC plan blocks alternative uses of many channels in most major metropolitan areas. However, although the overall potential for reallocation is greater under the FCC plan.

Motorola Channel Plan. Motorola, Inc. in its comments to the Sixth Notice (Motorola Comments) submitted an alternative channel plan that, like that of the broadcasters, was based on the FCC core plan. Motorola used the FCC table as its basis, but placed a higher penalty on placing any DTV assignments on channels 60-69 and placed a greater emphasis on protecting adjacent channel (or co-channel in the case of Boston, MA to New Haven, CT) distances between DTV and land mobile operations. In addition, Motorola found some discrepancies in the FCC core table, such as allotting a DTV channel only two miles from land mobile channels now being shared.³²

The plan reduced television use of channels 60-69 to only five television assignments, rather than the 30 in the FCC's table. Motorola conducted a second analysis and allowed short spacing between DTV stations down to 100 km (175 km was the FCC plan) and reduced the number of assignments in channels 60-69 to two. The analysis resulted in DTV to DTV short spacing in twelve instances (24 stations involved). The Motorola plan thus freed all but channels 61 and 69 for reallocation on a nationwide basis. Channel 61 would be used for DTV in Newton, NJ, and channel 69 would be used for DTV in Stockton, CA.

Plans Versus Needs. One of the fundamental observations with the analysis to this point is that the public safety community has its greatest need for spectrum today while the broadcasters' need for spectrum is in the future. With time, technology reduces the public safety spectrum requirement. Concurrently, the broadcast community will have its greatest need in the future during the transition phase to DTV. After full implementation of DTV, the broadcasters' need for spectrum will also diminish. The differences in the time lines for each service gives rise to the possibility of increased spectrum sharing almost immediately.

³¹ See Broadcast Comments at page 45.

³² See Motorola Comments at page 2.

Without regard to policy reasons why one of the three proposed channel plans might be adopted by the FCC, it appears that any of the three could lead to spectrum relief for the public safety community in the near and long terms. Again referring to page A.7 of Appendix A, most communities in the country need no more than 3.0 MHz of spectrum from now until the year 2010. That constitutes half of one television channel, a fourth of a channel from two television channels, or some other combination. Such "sliver sharing" of spectrum can likely be accommodated in most communities throughout the country.

The larger communities have such mammoth capacity needs that an aggressive move to new land mobile technology should be undertaken immediately. Simply throwing massive quantities of spectrum their way will not solve the capacity problem even if spectrum could be identified in the short term. If 6.25 kHz equivalent technology were to be employed immediately by New York, Los Angeles, and Chicago for all new systems, they would never reach the predicted interim levels. This means that rather than keeping 25.0 kHz equipment on the air and then transitioning through 12.5 kHz equivalent technology, as contemplated by the FCC's Refarming proceeding and the PSWAC report, major metropolitan areas should begin to look at the most advanced technologies available and begin to install them today. The spectrum needs in these areas do not permit the luxury of even contemplating 12.5 kHz technology even as an interim step if more efficient technology can be introduced. Such a decision to move to high efficiency technology does not even require FCC action. Each community could take steps to ensure that new systems meet tomorrow's efficiency standards. This would include the 800 MHz and 900 MHz bands as well as the Refarming bands below 512 MHz.

Sliver Sharing Example. In the interest of equipment availability for the public safety community, the range of channels to be considered for reallocation, full channel sharing, or sliver sharing should be limited. It makes sense to consider channels 60 - 69 for sliver sharing. The specifics of how further sharing might be accomplished on a nationwide basis depends entirely on the television spectrum plan adopted by the FCC. It is possible, however, to examine a representative metropolitan area and determine what sharing options exist. Atlanta, for example, has a calculated need of 3.0 MHz. Appendix B provides an analysis for Atlanta, Georgia. Atlanta was chosen because it is in the top 20 markets and has a full powered television channel 69 which immediately wipes out use of two channels. Even under those conditions, sharing options were found under all three plans.

Under the Motorola plan all channels, 60 - 69 would be available for land mobile sharing, as no DTV television channels would be in the area. The only immediate restrictions would be to protect existing NTSC stations.

For the FCC DTV plan, the following assumptions were used for the spectrum search:

1. Only channels 60 - 69 would be considered.
2. Atlanta retains a full powered channel 69 station for the medium future.
3. Co-channel distances to television stations would be at least 162 miles for NTSC stations and 155 miles for DTV allotments. These values are those currently being used for channels 14 - 20 NTSC sharing and the FCC proposed mileages for DTV sharing.
4. Adjacent channel distances to television stations would be at least 67 miles for NTSC and 110 miles for DTV. These values are those currently being used for channels 14-20 NTSC sharing and the FCC proposed mileages for DTV sharing.
5. The 3.0 MHz would come from the center of one television channel with 1.5 MHz guard bands on both sides of the public safety spectrum.

Given all of the parameters, the table in Appendix B, (page B.1), shows that sliver sharing appears possible on television channels 65 and 67 in Atlanta. (Any column with no "X" marks meets all of the mileage criteria outlined above.) Similar analyses could be conducted for other cities based on the final television channel plan.

Finally, the study was conducted using only the DTV assignments of the broadcasters' plan. The results of this study are shown in Appendix B, (page B.2). Both channels 65 and 67 were earmarked for DTV assignments under the broadcasters' plan. However, these channels would be available for public safety sharing until they were needed for DTV transmissions. Upon full implementation of DTV (NTSC channels off the air), channel 63 becomes available for potential public safety sharing. In addition, with minor short spacing, channels 60 and 69 are potentials for additional long term sharing. With an appropriate transition plan, public safety entities could have at least one television channel available to help meet spectrum needs in Atlanta beginning now and continuing past 2010. Although such sliver sharing may not solve all of the public safety needs, it can provide a good beginning to finding the needed spectrum.

CONCLUSIONS AND RECOMMENDATIONS

The spectrum needs of the public safety community for frequencies below 1,000 MHz are relatively low outside the most populated areas of the country, based on calculated needs using the formula developed by the PSWAC. Many of those needs can be accommodated by further sharing of the UHF television spectrum between public safety entities and television broadcasters. To facilitate meeting the spectrum needs of public safety, it is recommended that MSTV support the following initiatives:

1. The Department of Defense should be encouraged to make 2.5 MHz of spectrum available for nationwide interoperability channels in the 380.0 - 399.9

MHz band. For a number of reasons, as contained in this report, the DoD spectrum is best suited for interoperability operations.

2. Develop incentives to prompt the land mobile community to convert to the most spectrum efficient equipment available as soon as possible, especially in major metropolitan areas. Sufficient communications capacity can only be obtained through use of efficient equipment in areas like New York, Los Angeles, and Chicago. Spectrum needs in these markets do not permit the luxury of transitioning through 12.5 kHz equipment to get to 6.25 kHz equipment. Such incentives could include:

- a) a licensee could not access new spectrum until equipment operating in existing spectrum meets a 6.25 kHz bandwidth equivalent standard,**
- b) a licensee would have to turn in existing spectrum before being licensed in new spectrum, and then licensing would be for only 6.25 kHz equivalent technology,**
- c) a licensee could gain exclusivity of an existing channel if the equipment was converted to 6.25 kHz bandwidth equivalent technology,**
- d) a licensee on a conventional two-way channel not utilizing trunking, TDMA, or other efficient technology would be relicensed as a secondary user of a channel, or**
- e) mandatory transition dates to convert to 6.25 kHz equivalent bandwidth equipment.**

3. Apply Refarming channel guidelines to the 800 MHz and 900 MHz land mobile bands to create more capacity and provide the potential for reallocation from non-public safety land mobile use to public safety use. In addition, any new systems, regardless of band, should be required to meet a 6.25 kHz equivalent bandwidth standard.

4. In conjunction with the public safety community, conduct a city-by-city study to determine nationwide availability of "sliver sharing" on television channels 60 - 69 to help meet the short-term spectrum needs of public safety entities.